5G Radio Access Technology

Nitin Chandrakant Kuamvat[1] Anagha Kashinath Khaire[2]
[1,2]Department of Computer Engineering
[1,2]Institute of Management & Computer Studies, Thane, Maharashtra, India

Abstract— In parallel with the proliferation of smartphones, LTE services that can provide data transmission at even higher bit rates with low latency and high efficiency have been spreading rapidly, and the worldwide rollout of LTE-Advanced as an evolved form of LTE has already begun. Nevertheless, the need for further improvements in user QoE and system performance will surely increase going forward, and in anticipation of this need, studies on the next-generation mobile communications system (5G) have begun. This article describes the direction of technology development and promising component technologies for 5G RAT.

Key words: Fraud and Malware Detection, Google Play

I. INTRODUCTION

Radio communications systems in mobile communications have undergone major changes about every ten years starting with the first generation (1G) employed in the 1980s and evolving into the current fourth generation (4G) in the form of LTE/LTE-Advanced (Figure 1). There are key technologies for each of these generations, such as Code Division Multiple Access (CDMA) for 3G and Orthogonal Frequency Division Multiple Access (OFDMA) and Multiple Input Multiple Output (MIMO) for 4G. The fifth generation (5G), however, will differ from previous generations in that priority will be placed on meeting specific requirements, namely, ultra-high data rate, ultra-high system capacity, ultra-low latency, massive device connectivity, and low power consumption, rather than on implementing completely new, pioneering technology. Here, the key issue will be how to combine a variety of component technologies in the best way to meet these requirements as Radio Access Technology (RAT) matures. In this article, we survey the evolution of RAT toward 5G and describe key technologies from a 5G radio access perspective toward enhanced Mobile Broad Band (MBB) and the Internet of Things (IoT) era.

II. EVOLUTION OF RAT TOWARD 5G

A. *Ultra-High Data Rate, Ultra-High System Capacity Approach*

The 5G system must achieve a dramatic leap in performance. Specifically, it must provide ultra-high data rate and ultra-high system capacity 100 times and 1,000 times, respectively, that of 2010, the first year of LTE services [1]. Here, we can consider the approach shown in Figure 2 as a solution to increasing capacity. This approach combines technology for improving spectrum efficiency (Fig.2(1)), technology for effectively using wider band- widths in a variety of frequency bands (Fig. 2 (2)), and technology for operating small cells in dense deployments (Fig. 2 (3)). If, by this approach, spectrum efficiency per cell (bps/Hz/cell), frequency bandwidth (Hz), and number of cells per unit area (cell/km^2) in Fig. 2 (1), (2), and (3), respectively, can each be improved by ten times, a calculation of radio communications capacity per unit area (bps/km^2) will give a value of 1,000 times existing capacity (corresponding to the volume of the cube appearing in the figure). In addition, applying technologies such as high-efficiency offloading of traffic to wireless LAN is likewise an effective approach to increasing capacity that can be introduced in a mutually complementary manner (Fig. 2 (4)).

At the same time, extending and making effective use of frequency band- width in the next-generation mobile communications system will require the exploitation of higher frequency bands in addition to existing frequency bands used by 3G and 4G, and increasing the number of cells will invite higher net- work costs and increased power consumption. More efficient construction and operation methods are therefore needed. Further improvements in spectrum efficiency are also necessary as described above. In 5G, the above objectives must be achieved through novel designs and effective technical solutions.

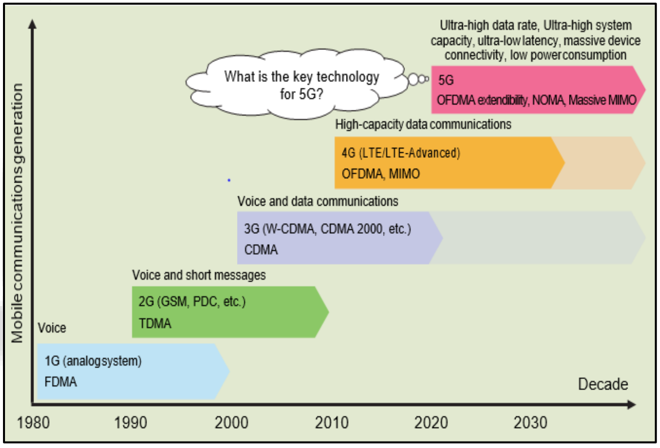

Fig. 1: Evolution of Mobile Communications Systems & Representative Technologies of Each Generation

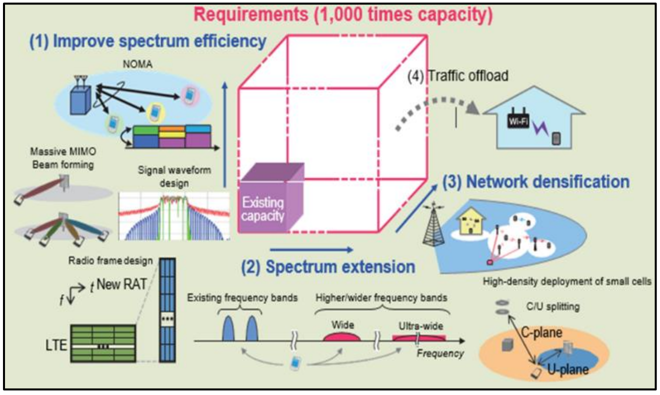

Fig. 2: Evolution of RAT toward 5G

B. *C/U Splitting (Phantom Cell)*

NTT DOCOMO has proposed the Phantom cell concept as a means of linking different frequency bands and different RATs [2]. As shown in Figure 3, this refers to a network configuration that uses C/U splitting in which the Control Plane (C-plane) and User Plane (U-plane) are split between a macro cell and multiple instances of a small cell. Much like

Advanced Centralized Radio Access Network (C-RAN) [3] architecture based on LTE-Advanced Carrier Aggregation(CA) technology, this Phantom cell makes it easy to expand a cell to higher frequency bands without complicating mobility management and control as in handover or other processes. Furthermore, as a feature not provided by Advanced C-RAN, the Phantom cell represents technology that can achieve C/U splitting even in a distributed base station configuration. In other words, it enables CA technology to be applied even among different base stations with separate baseband units.

Phantom cell technology also ne- gates the need for a physical cell ID in small cells using higher frequency bands, and compared with existing LTE/LTE-Advanced, it can accommodate advanced functional extensions such as virtualization technology for virtualizing cell IDs and technology enabling terminals to efficiently discover small cells [4]. One component technology related to Phantom cells is Dual Connectivity (DC), whose specifications have already been completed at the 3rd Generation Partnership Project (3GPP) as small-cell enhancement technology in LTE-Advanced. The Phantom cell is also basic to the 5G radio access concept of supporting both low and high frequency bands by combining enhanced LTE (e LTE) and New RAT.

C. *New RAT Design*

1) Support of Flexible Radio Parameters In 5G, the introduction of New RAT, while allowing for non-backward compatibility with LTE, must mean a significant increase in performance. Specifically, to achieve bit rates of 10 GBPS and greater, New RAT must support higher frequency bands in addition to wider bandwidths from several hundred MHz to 1 GHz and higher. However, the effects of phase noise can be large in high frequency bands, so there is a need here to improve resistance to phase noise such as by optimizing radio parameters. For example, LTE applies Orthogonal Frequency Division Multiplexing (OFDM) with a subcarrier interval of 15 kHz as a signal format. However, as shown in Figure 4, widening the subcarrier interval (shortening the OFDM symbol length) in high frequency bands can reduce the effects of interference between subcarriers and improve resistance to phase noise.

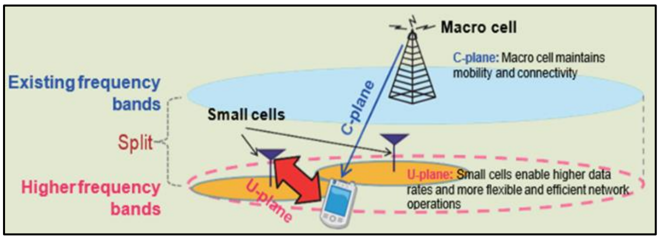

Fig. 3: Concept of C/U Splitting (Phantom Cell)

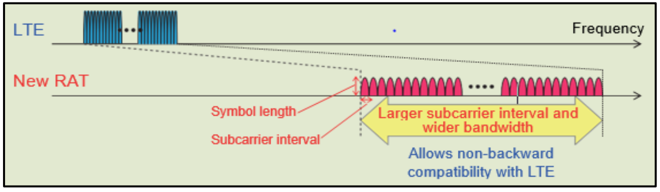

Fig. 4: New RAT Design based on Scaling Radio Parameters of LTE

Here, a design that enables LTE radio parameters to be changed in a scalable manner according to the frequency band in use is an effective method for achieving radio parameters ideal for high frequency bands. An advantage of such a design is that terminals supporting both LTE and New RAT (dual mode) and terminals that can simultaneously connect to both low and high frequency bands (DC) would be relatively easy to implement. Furthermore, since the packet Transmission Time Interval (TTI) can be simultaneously shortened by the shortening of the OFDM symbol length (lower left in Fig. 2), latency in the radio access interval can also be reduced.

2) High efficiency Radio Frame Configuration In New RAT, a high-efficiency radio frame configuration is deemed necessary. For example, LTE features a Cell-specific Reference Signal (CRS) that is mapped and widely dispersed along the time and frequency axes for use in data demodulation and mobility measurement (Figure 5). However, a base station will regularly transmit CRS even during periods of no data traffic. These signals can therefore be a waste of energy while also interfering with other cells in environments having a dense deployment of cells as in urban areas.

Thus, for New RAT, studies are being performed on a high-efficiency radio frame configuration featuring a transmission gap at times of no data traffic. This is accomplished by transmitting the least number of reference signals needed for mobility measurement at relatively long intervals and in a local manner. In this case, reference signals for demodulation will be multiplexed with user-specific data signals. In addition, shortening of the TTI length means that data signals can be transmitted in even shorter time periods, which means that a reduction in power consumption can be expected.

Furthermore, considering the need for supporting a variety of scenarios (such as Device-to-Device (D2D), radio backhaul, and multi-hop communications) that will be using New RAT in the future, a radio frame configuration with high symmetry between the uplink and downlink would be desirable.

III. COMPONENT TECHNOLOGIES FOR 5G RADIO ACCESS

The following describes key component technologies for 5G radio access. We omit description about Massive MIMO technology here since it is introduced in another special article in this issue.

A. *Waveform Design*

From the point of view of signal waveform, MBB/IoT-related scenarios in the 5G system are targets of consideration (Figure 6). For MBB, coverage extendibility and propagation delay must be dealt with, extendibility to high frequency bands should be provided, and robustness to changing propagation channels in a high-speed mobile environment should be achieved. In the case of IoT, support for short packet transmission and asynchronous access in Machine Type Communications (MTC) should be provided.

As shown in Figure 7, an effective approach here in 5G is to apply different radio parameters and waveform designs according to the frequency band and frequency bandwidth to be used and the application environment as well.

For example, in 5G, we can consider that OFDM-based multi-carrier transmission would be an effective candidate for signal waveforms and that a wide variety of frequency bands could be supported by applying variable radio parameters. However, from the view- point of supporting ultra-wide band- widths (of several GHz) in very high frequency bands (above MIMO and can achieve high spectrum efficiency under multipath conditions in wide- bandwidth transmission. OFDM or new signal waveforms based on OFDM should facilitate the support for a wide variety of services.

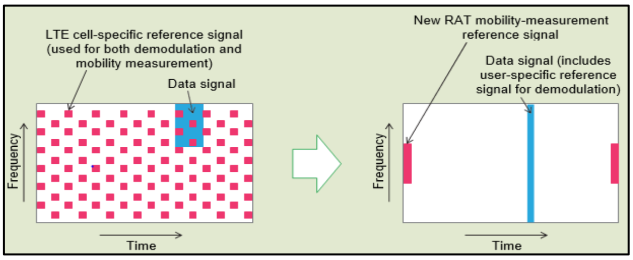

Fig. 5: High Efficiency Radio Frame Configuration

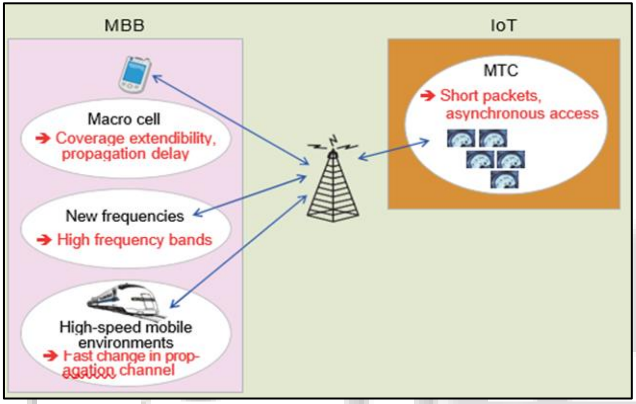

Fig. 6: Examples of MBB/IoT Related Scenarios in 5G

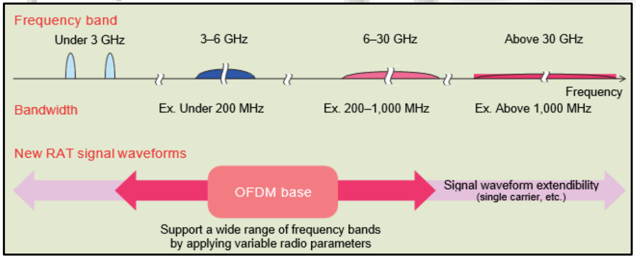

Fig. 7: Examples of Candidate Signal Waveforms for Various Frequency Bands

With the above in mind, signal waveforms need to have "high spectrum efficiency," "high localization in frequency/time domains (guard-band reduction by suppressing out-of-band in the frequency domain and limited time response by limiting trans- mission-signal spreading in the time domain)," and "high orthogonality be- tween subcarriers (affinity with channel estimation method and other technologies such as MIMO)." To satisfy these requirements, we are studying new signal waveforms that apply a filter to OFDM signals. In the following, we de- scribe Filter Bank Multi Carrier (FBMC), Universal Filtered OFDM (UF-OFDM), and Filtered OFDM (F-OFDM) as new alternative signal waveforms toward 5G. In Figure 8, we present the frequency- and time-domain responses for OFDM applying a Cyclic Prefix (CP) (CP-OFDM), which has already been introduced in the LTE downlink, and for the above-mentioned new alternative wave- forms for 5G.

3) FBMC

FBMC applies a filter in units of subcarriers. It applies, in particular, a filter with steep frequency characteristics to maintain orthogonality between subcarriers, but out-of-band radiation is small compared with the other waveforms. On the other hand, the signal waveform response has a wide spread in the time do- main, which raises concerns about an increase in overhead and an in- crease in delay time when applying short packets.

4) UF-OFDM

UF-OFDM applies a filter in sub-band units. It prevents inter-symbol interference by inserting a guard interval (no-transmission interval) for each symbol instead of a CP. Compared with FBMC, its out- of-band radiation is large, but its waveform spread in the time domain is small. UF-OFDM is therefore applicable to short packets and asynchronous access and is effective in shortening delay time.

5) F-OFDM

F-OFDM applies a filter in units of sub-bands while maintaining CPs. The insertion of CPs here makes the use of a guard interval unnecessary, so a filter with a long filter length can be applied compared with UF- OFDM. However, compared with FBMC, the time spread of the wave- form can be made small. Inter-symbol interference will occur since the edge of the filter exceeds the CP interval, but selection of an appropriate filter can minimize that effect. Similar to UF-OFDM, F-OFDM can be applied to short packets and asynchronous access and it is effective for shortening delay time.

With the aim of providing 5G ser- vices in 2020, NTT DOCOMO is collaborating with 13 leading international vendors to accelerate standardization and commercial development and is vigorously promoting 5G studies [5].

In terms of new signal waveforms, we are conducting experimental trials on FBMC and UF-OFDM with Alcatel-Lucent and on F-OFDM with Huawei. We are also collaborating with DOCOMO Communications Laboratories Europe on detailed studies to compare and evaluate the benefits of different types of signal wave- forms and their affinity with MIMO [6].

B. *Dynamic TDD & Flexible Duplex*

Mobile communications systems up to 4G basically applied either Frequency Division Duplex (FDD) that separates the uplink and downlink in the frequency domain or Time Division Duplex (TDD) that separates the uplink and downlink in the time domain. However, in mobile communications using wide frequency bands as envisioned for 5G, the possibility exists of applying different types of duplex schemes to different types of frequency bands, so there is a need for "flexible duplex" that can sup- port various types of duplex schemes in a flexible manner. To this end, it would be desirable to support an extension to dynamic TDD that can dynamically change the ratio of downlink sub frames and uplink sub frames (DL/UL configuration) in TDD, and to support the Phantom cell concept that performs C/U splitting among different frequency bands regardless of the duplex schemes used in those bands. In short, component technologies for “flexible duplex” in 5G can encompass flexible selection and simultaneous connection of communication links such as FDD, TDD, or for that matter, TDD DL only or TDD UL only (one-way TDD in either the downlink or uplink), as well as technology for adaptively selecting frequency bands including unlicensed bands, technology for achieving CA/DC, and countermeasures to interference between the uplink and downlink in such duplex communications.

C. NOMA

1) *Overview*

Multiple access methods in mobile communications systems evolved from Frequency Division Multiple Access (FDMA) in 1G to Time Division Multiple Access (TDMA) in 2G and CDMA in 3G, while 4G uses OFDMA that preserves orthogonality among users by multiplexing them over adjacent resources in the frequency domain. In contrast, Non-Orthogonal Multiple Access (NOMA), which is now under study for 5G, is a multiple access method that exploits the power domain to intentionally multiplex users in a non-orthogonal manner over the same resources in the frequency domain. Thus, when applied to the downlink, signals intended for multiple users within a cell are combined and transmitted simultaneously using the same radio resource by the base station. This scheme is expected to further improve spectrum efficiency and is considered to be a promising component technology for LTE evolution and 5G [7].

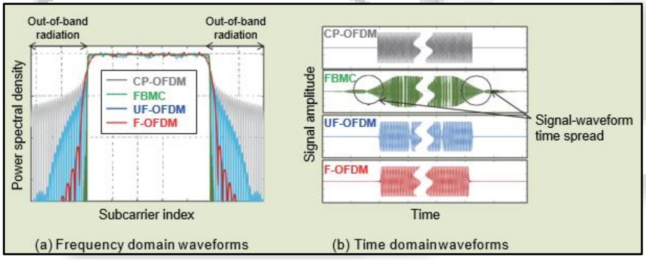

Fig. 8: Response of Various Signal Waveforms in Frequency/Time Domains

2) *Basic Principle*

The basic principle of the NOMA method is shown in Figure 9. Among User Equipment (UE) connected within a cell with their downlinks as a target, the base station selects a pair of terminals with one near the base station in the center of the cell having good reception (UE1 in the figure) and the other near the cell’s edge having poor reception (UE2 in the figure), and multiplexes and transmits the signals to those terminals using the same time slot and same frequency resource. Here, more transmit power is allocated to the signal intended for UE2 than to the signal intended for UE1. Now, turning to the receive side, inter-user interference occurs at UE1 near the base station since this terminal receives a multiplexed signal consisting of UE1 and UE2 signals. However, a simple interference cancellation process can be used to separate these two signals as long as a certain power difference exists between them.

For example, at UE1 near the base station, such a process can first decode only the signal intended for UE2 that has been allocated strong transmit power and use this decoded signal to create a signal replica, which can then be subtracted from the receive signal before separation after which the signal intended for UE1 can be decoded. This signal separation process is called Successive Interference Cancellation (SIC), and while it has been under study since the 3G era, the need for advanced processing on the terminal side has made it difficult to implement. Today, however, rapid progress in terminal processing power will make such technology feasible in the near future.

Next, on the UE2 side, the fact that low transmit power has been allocated to the UE1 signal that constitutes an interference signal to the UE2 signal means that the signal intended for UE2 can be directly decoded without applying SIC. In addition, the need for applying NOMA can be dynamically selected in sub frame units in the base station’s scheduler, which means that NOMA can coexist on a network that supports existing LTE/LTE-Advanced terminals.

NOMA can also be combined with technologies that are being applied in LTE. For example, combining NOMA with MIMO in LTE would make it possible to multiplex data streams at a number exceeding the number of transmit antennas thereby increasing system performance.

6) Performance Evaluations & Transmission Experiments

To assess the effectiveness of NOMA, NTT DOCOMO performed performance evaluations using computer simulations and transmission experiments using prototype equipment [8] [11]. In this study, the radio frame configuration was based on that of LTE Release 8 and the target of these evaluations was Transmission Mode 3 (TM3) and Transmission Mode 4 (TM4) That respectively does not and does feedback a user Precoding Matrix Index (PMI) to the base station.

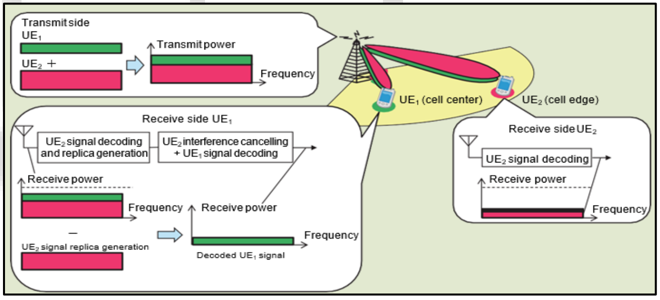

Fig. 9: Basic Principle of NOMA

1) NOMA Link Level Evaluation

Given the application of a Code Word level SIC (CWIC) receiver, Figure 10 shows multiplex power ratio (P1) of a cell-center user versus required Signal to Noise Ratio (SNR) for which Block Error Ratio (BLER) of the cell-center user applying CWIC satisfies 10^{-1}. Here, we set the number of multiplexed users to 2 and applied 2-by-2 closed- loop Single User (SU)-MIMO (in which feedback information from the user terminal is unnecessary) based on LTE TM3 [12]. The Modulation and Coding Scheme (MCS) of each user was 64 Quadrature Amplitude Modulation (64QAM) (code rate: R = 0.5) for the cell center user and Quadrature Phase Shift Keying (QPSK) (R = 0.49) for the cell-edge user. Furthermore, in combining NOMA and MIMO, there are multiple combinations of the number of MIMO transmission streams (transmission rank) for each user as determined by the receive quality at each user’s terminal. In this study, we used three combinations of rank values for the cell-center user and cell-edge user (R1 : R2), namely, 1:1, 2:1, and 2:2. Additionally, for comparison purposes, the figure includes characteristics for Orthogonal Multiple Access (OMA) applied in LTE (i.e., OFDMA). Now, examining these results, it can be seen that the effects of inter-user interference increased and required SNR increased in the region corresponding to P1 greater than 0.4. However, in the region corresponding to P1 from 0.2 to 0.4 in which the probability of applying NOMA multiplexing is high, about the same required SNR was achieved as that when applying OMA. This result indicates that CWIC has high interference cancellation performance.

2) NOMA System Level Evaluation

The results of a system level evaluation of throughput gain by NOMA over OMA are listed in Table 1. Here, we set the number of multiplexed users to 2 and the antenna configuration to 2-by-2, and applied LTE TM3 and TM4 [12]. Furthermore, assuming that inter- user interference can be ideally cancelled out, we show results for sub- band scheduling that performs resource allocation and MCS selection in sub-band units and wideband scheduling that performs resource allocation and MCS selection using the entire band. It can be seen from these results that NOMA achieves a gain over OMA in all cases, and when applying TM3 and Case 3, that NOMA improves cell throughput and cell-edge user throughput by 30.6% and 34.2%, respectively. These results demonstrate that NOMA has an enhancement effect with respect to user throughput.

Results of measurements using prototype transmission equipment finally, we present the results of an experiment in an indoor radio- wave environment using prototype equipment. This NOMA prototype equipment is shown in Figure 11 (a) and examples of measurement results are shown in Fig. 11 (b). As shown in Fig. 11 (a), UE1 and UE2 are both stationary, the former installed near the base station and the latter at a point about 50 m from the base station (to the right outside the view in the photo). On evaluating throughput characteristics when applying 2-by-2 SU-MIMO, results showed NOMA could obtain a gain of approximately 80% over OFDMA.

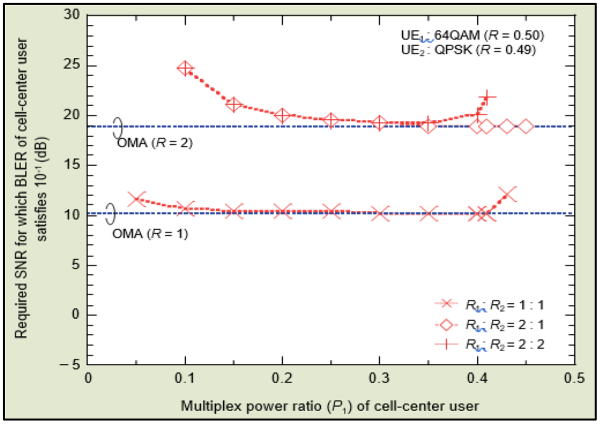

Fig. 10: NOMA Link Level Evaluation Result

		2 × 2 MIMO, TM3			2 × 2 MIMO, TM4		
		OMA	NOMA	Gain	OMA	NOMA	Gain
Case 1: Sub-band scheduling and sub-band MCS selection	Cell throughput	21.375	27.053	26.56 %	21.97	27.866	26.84 %
	Cell-edge user throughput	0.472	0.633	34.11 %	0.544	0.777	42.83 %
Case 2: Sub-band scheduling and wideband MCSselection	Cell throughput	21.59	26.29	21.77 %	22.291	27.499	23.36 %
	Cell-edge user throughput	0.476	0.62	30.25 %	0.552	0.769	39.31 %
Case 3: Wideband scheduling and wideband MCSselection	Cell throughput	19.068	24.894	30.55 %	19.577	25.515	30.33 %
	Cell-edge user throughput	0.401	0.538	34.16 %	0.451	0.649	43.90 %

Table 1: NOMA System Level Evaluation Result

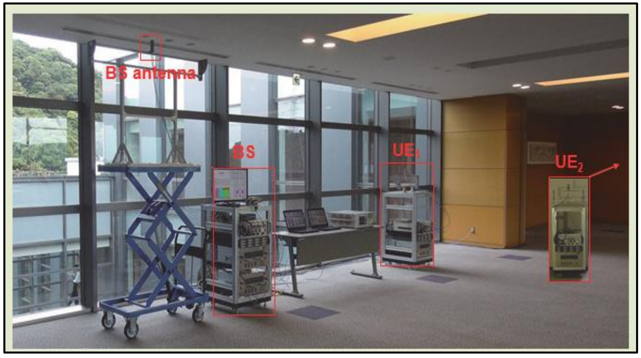

Fig. 11(a): External View of NOMA Prototype Transmission Equipment (Indoor Experiment Environment)

New multiple access methods using non-orthogonal schemes in this way have been attracting much attention in recent years and have been taken up as key topics in overseas projects and inter- national conferences [13]. In particular, study of these methods commenced in April 2015 at 3GPP, a leading international standardization body, as a Study Item (SI) for LTE Release 13 [14] [15]. In addition, NTT DOCOMO is evaluating NOMA in the uplink in addition to the downlink in a collaborative project with DOCOMO Beijing Communications Laboratories [7] [16].

D. *IoT-Related Technologies*

In 5G, it is essential that support be provided for IoT in addition to MBB. However, IoT covers a variety of categories with a variety of requirements, and the New RAT design would need to be tailored to each category to meet the requirements. In IoT, key categories that are now attracting attention are massive Machine Type Communications (mMTC) and Ultra-Reliable and Low Latency Communications (URLLC) [13].

One example of mMTC is a large number of sensors that send out small and short packets. In this case, the design of signal waveforms that support cover- age expansion and asynchronous communications is important. In addition, mMTC would benefit from NOMA [16] in the uplink to improve control channel capacity and increase the number of simultaneously connected devices, and it would also benefit from the design of a control channel that requires no control information (e.g., a channel access method that makes pre-authorization when transmitting data unnecessary (grant free access)). Next, an example of URLLC would be a service like autonomous driving. Key technologies for sup- porting URLLC would be high-speed uplink/downlink switching and mobile edge computing to exploit the low la- tency features of the 5G New RAT [17]. Furthermore, in the case of automobiles and trains in which mobility is an issue, group mobility and mobile backhauling take on importance [18].

IV. CONCLUSION

This article described the 5G radio access technology concept and the promising component technologies for realizing it. The idea here is to effectively combine a wide range of frequency bands from existing low frequency bands to the Extremely High Frequency (EHF) band to both maintain coverage and increase capacity while expanding bandwidth.

The 5G New RAT therefore needs to be designed to support such a wide range of frequency bands from existing frequency bands to higher frequency bands. Looking to the future, NTT DOCOMO is committed to exploring new ways to further improve spectrum efficiency by studying both frequency-band-specific technologies and frequency-band-agnostic technologies.

REFERENCES

[1] Y. Kishiyama et al.: “NTT DOCOMO 5G Activities—Toward 2020 Launch of 5GServices—,” NTT DOCOMO Technical Journal, Vol.17, No.4, pp.4-15, Apr. 2016.
[2] H. Ishii, Y. Kishiyama and H. Takahashi: “A Novel Architecture for LTE-B: C-plane/U-plane Split and Phantom Cell Concept,” Proc.Of IEEE Globecom, Dec.2012.
[3] NTT DOCOMO Press Release: “DOCOMO Verifies Advanced C-RAN in Outdoor Commercial Environment for Stress free Communications in High-traffic Areas,” Feb. 2015.
[4] 3GPP TR36.842 V0.2.0: “Study on Small Cell Enhancements for E-UTRA and EUTRAN—Higher Layer Aspects,” May 2015.
[5] NTT DOCOMO Press Release: “DOCOMO to Collaborate on 5G with Five Additional Vendors—Expands 5G collaborations to 13 world-leading vendors—,” Jul. 2015.
[6] Benjebbour, Y. Kishiyama, K. Saito, P.Weitkemper and K. Kusume: “Study on Candidate Waveform Designs for 5G,” Proc. of IEICE Gen. Conf. ’15, B-5-9, pp.454, Mar. 2015.
[7] Benjebbour, A. Li, Y. Kishiyama, J. Huiling and T. Nakamura: “System- Level Evaluations of SU-MIMO Combined with NOMA,” Proc. of IEEE Globecom, Dec. 2014.
[8] Y. Saito, A. Benjebbour, Y. Kishiyama and T. Nakamura: “System-Level Performance Evaluation of Downlink Non Orthogonal Multiple Access (NOMA),” Proc. of IEEE PIMRC, Sep. 2013.
[9] Y. Saito, A. Benjebbour, Y. Kishiyama and T. Nakamura: “System-Level Performance of Downlink Non-Orthogonal Multiple Access (NOMA) under Various Environments,” Proc. of IEEE VTC 2015-Spring, May 2015.
[10] K. Saito, A. Benjebbour, A. Harada, Y.Kishiyama and T. Nakamura: “Link-Level Performance of Downlink NOMA with SIC Receiver Considering Error Vector Magnitude,” Proc. of IEEE VTC 2015- Spring, May 2015.
[11] K. Saito, A. Benjebbour, Y. Kishiyama, Y.Okumura and T. Nakamura: “Performance and Design of SIC Receiver forDownlink NOMA with Open-Loop SU-MIMO,” Proc. of IEEE ICC, Jun. 2015.
[12] METIS home page. https://www.metis2020.com/
[13] 3GPP RP-150496: “New SI Proposal: Study on Downlink Multiuser Super-position Transmission for LTE,” Mar.2015.
[14] 3GPP R1-152493: “Candidate Schemes for Superposition Transmission,” May 2015.
[15] X. Chen, A. Benjebbour, A. Li and A.Harada, “Multi-User Proportional Fair Scheduling for Uplink Non-Orthogonal Multiple Access (NOMA),” Proc. of IEEE VTC2014-Spring, May 2014.
[16] T Shimojo, et al.: “Future Core Network for 5G Era” NTT DOCOMO Technical Journal, Vol.17, No.4, pp.50-59, Apr. 2016.
[17] H. Yasuda, J. Shen, Y. Morihiro, Y. Morioka, S. Suyama and Y. Okumura: “Challenges and Solutions for Group Mobility on 5G Radio Access Network,” IEICE Technical Report, Vol.114, No.180, RCS2014-144, pp.31-36, Aug. 2014 (in Japanese).